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RECENT CLIMATIC TREND

By L. F. LEWIS, M.Sc.

The upward trend of temperature in the northern hemisphere has recently aroused a lively interest among meteorologists and others in Europe and America.

The 5-year volume of meteorological observations published by the trustees of the Radcliffe Observatory, Oxford, in 1932, contains an appendix by Dr. Knox Shaw and Mr. J. G. Balk giving, among other data, monthly values of mean temperature going back to 1815. The data were scrutinised by the authors of this appendix and corrections necessitated by changes of instrument and exposure were applied, and thus we have as homogeneous a set of observations as is possible over so long a period.

A detailed analysis of the data was made and published in *Professional Notes No.* 77*. In the latter part of the paper the figures were examined with reference to the secular trend of temperature and curves of 20-year running averages were drawn for the year and each of the four seasons. These curves, which are given in Fig. 1, have now been extended up to February 1950 and show some interesting and significant features.

The annual curve has continued to rise with minor fluctuations, and the final point on the graph representing the 20-year mean ending in 1949 is slightly higher than the previous record, which occurred in the 20-year means ending in 1836 and 1837. The winter curve fell from a large and extended maximum covering about the first 40 years of the 20th century to points well below the average in the 20-year means ending in 1947 and 1948. By February 1950 the curve had risen roughly to the long-period average, but as the curves are not smooth but irregular it may well be that the small minimum shown on this curve will prove to be part of a larger one. A similar value occurred in 1852 and 1853 during a minimum in that part of the 19th century.

The summer curve which has a minimum during most of the period of the recent winter maximum shows an equally significant change in the years since 1934. It has risen steadily and the value of the 20-year mean ending in 1949 is conspicuously higher than any previous 20-year mean throughout the whole period.

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*LEWIS, L. F.; Variation of temperature at Oxford, 1815–1934. *Prof. Notes met. Off., London*, 5, No. 77, 1937.

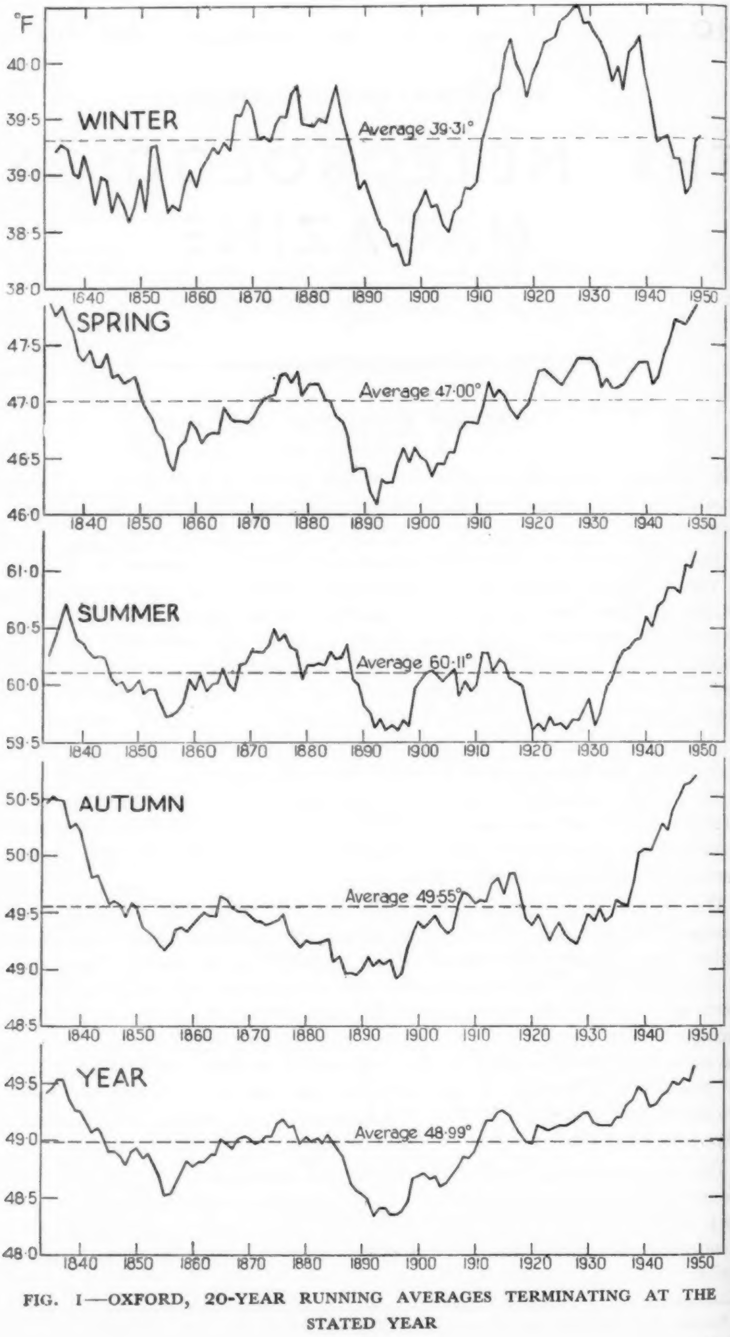

FIG. 1—OXFORD, 20-YEAR RUNNING AVERAGES TERMINATING AT THE STATED YEAR

The autumn curve shows changes similar to the summer curve, rising from a shallow minimum during the first part of the 20th century to a record high 20-year mean in the last 15 years.

The spring curve is very similar to the annual, and the mean for the 20 years ending in 1949 is practically equal to the previous highest means ending in 1834 and 1836.

Perhaps the most striking feature is the similarity between the beginning and the end of the curves, bearing in mind the long period covered by the data, and it is a temptation to suggest that in subsequent years the curves may, to some extent, be repeated. They will, however, continue to be irregular from point to point.

During the 15-year period since the figures were last analysed a number of records or near records have been established as is shown in the following table:—

(1) January 1940 was the coldest since the record cold January of 1838; mean temperature 29·2°F., 0·5°F. higher than in 1838.

(2) February 1947 was the coldest month during the whole period; mean temperature 27·3°F.

(3) March 1938 was the warmest March; mean temperature 49·1°F.

(4) April 1943 was the warmest April; mean temperature 52·1°F.

(5) August 1947 was the warmest August; mean temperature 66·3°F.

(6) September 1949 was the warmest September; mean temperature 62·3°F.

(7) November 1938 was the warmest November since the record warm month in 1818; mean temperature 49·3°F., 0·6°F. lower than in 1818.

(8) The year 1949 was the warmest year; mean temperature 51·6°F., 0·2°F. higher than in 1921.

UPPER FRONTAL ANALYSIS IN THE MEDITERRANEAN

By F. E. LUMB, M.Sc.

Upper cold fronts are not uncommon in the Mediterranean. Surface isobars may then be of no assistance in frontal analysis, especially if the isobaric pattern (or "constant-pressure-surface" pattern) changes rapidly with height. In placing upper cold fronts and estimating their present speed and future movement the contours of the 850-mb. surface are often useful. A good example is given by the front of October 10, 1948.

Example of October 10, 1948.—Fig. 1 shows the sea-level synoptic chart at 1500 G.M.T. on October 10, 1948. Fig. 2 shows the contours of the 850-mb. surface at 1500 also isopleths of the interval (thickness lines) between the 1000- and 850-mb. surfaces. Ascents for Tunis and Rome at 1500 were not available. The 0300 ascents were used with due allowance for solar heating as indicated by the 1500 surface temperatures. The figures for Sirte in Tripolitania were calculated, assuming a dry-adiabatic lapse rate up to 850 mb. (potential temperature 92°F.). This assumption is justifiable in hot desert air.

There is a striking contrast between the sea-level chart and the 850-mb. chart, due to the strong westerly thermal wind in the layer 1000–850 mb., which is a

common characteristic of belts of easterly or south-easterly surface winds in the Mediterranean. At 850 mb. the thermal " low " over Tripolitania has disappeared, and the essential feature of the synoptic situation—a marked trough from Sicily to west Tripolitania—is clearly revealed.

The approximate position of the upper front is known from previous analysis, but the joint use of the 1500 sea-level and 850-mb. charts enables the position of the front to be fixed with a fair degree of accuracy. Also the 850-mb. contour chart enables the forecaster to assess the future movement of the upper front, for which purpose the sea-level chart is useless. Although the surface wind is easterly between Sicily and Tripolitania, the 850-mb. chart shows that the upper front can be expected to move slowly eastward in this region.

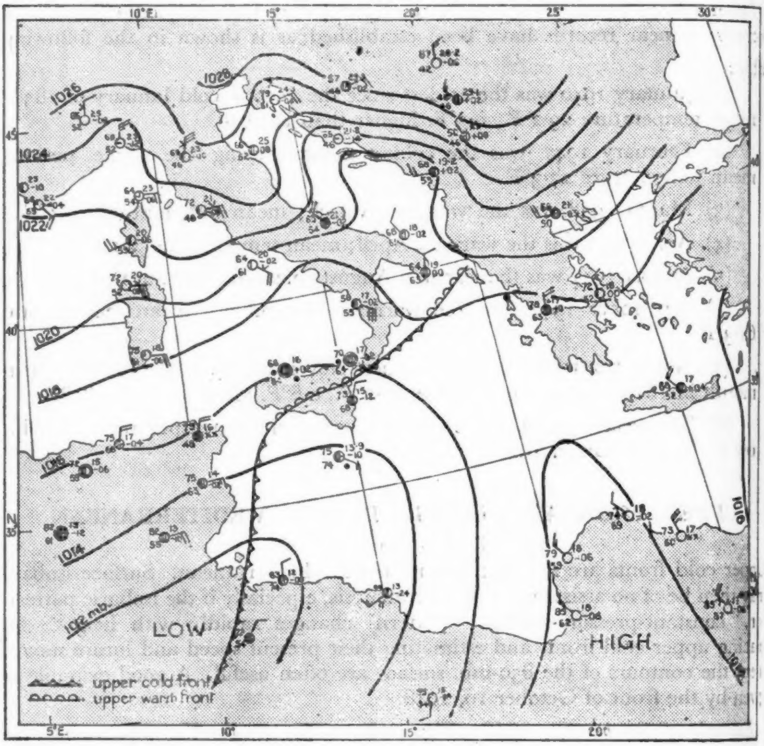

FIG. 1—SEA-LEVEL SYNOPTIC CHART, 1500 G.M.T., OCTOBER 10, 1948

Upper frontal analysis from thickness lines.—It has been shown how the 850-mb. contour chart can be used to tackle the problem of upper frontal analysis in the Mediterranean. The successful application of this method requires a good network of upper wind measurements at 850 mb.

In the *Meteorological Magazine* of July 1948 Dr. Sutcliffe* stresses the practical value of charts of thickness lines, and mentions their application to frontal

*SUTCLIFFE, R. C.; The use of upper air thickness patterns in general forecasting. *Met. Mag. London*, **77**, 1948, p. 145.

analysis. This line of attack is sometimes useful in detecting upper fronts when upper wind measurements to 850 mb. or higher are sparse or absent.

The essential clue to the presence of a thermally well marked, cold frontal surface on a thickness chart is a belt of relatively close thickness lines. The boundary of greater thickness is usually found close behind the axis of a " warm " ridge. For an upper frontal surface this boundary represents the foremost part of the cold air mass advancing aloft, *i.e.* the upper cold front, and can often be drawn with more or less accuracy, depending on the number

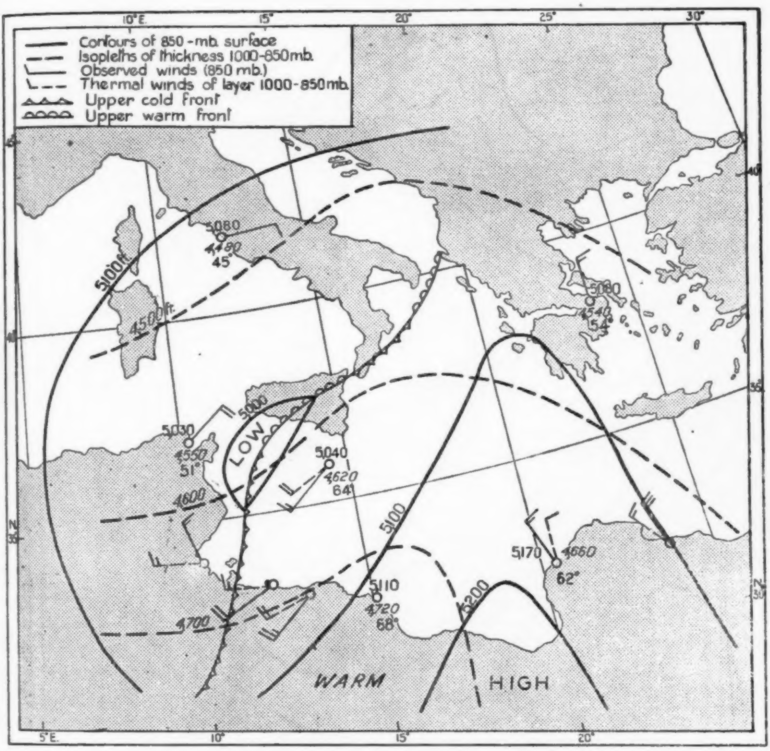

FIG. 2—850-MB. CONTOUR CHART, 1500 G.M.T., OCTOBER 10, 1948
Heights are given in feet, temperatures at the 850-mb. level in degrees Fahrenheit

and spacing of upper air soundings in the vicinity of the upper front. A more precise position of the upper front can be drawn on the sea-level synoptic chart after combining a study of the thickness pattern with cloud and weather observations at the surface and from aircraft—also sometimes surface pressure tendencies.

In using this method of upper frontal analysis, due allowance must be made for the thermal wind component perpendicular to the frontal surface. As

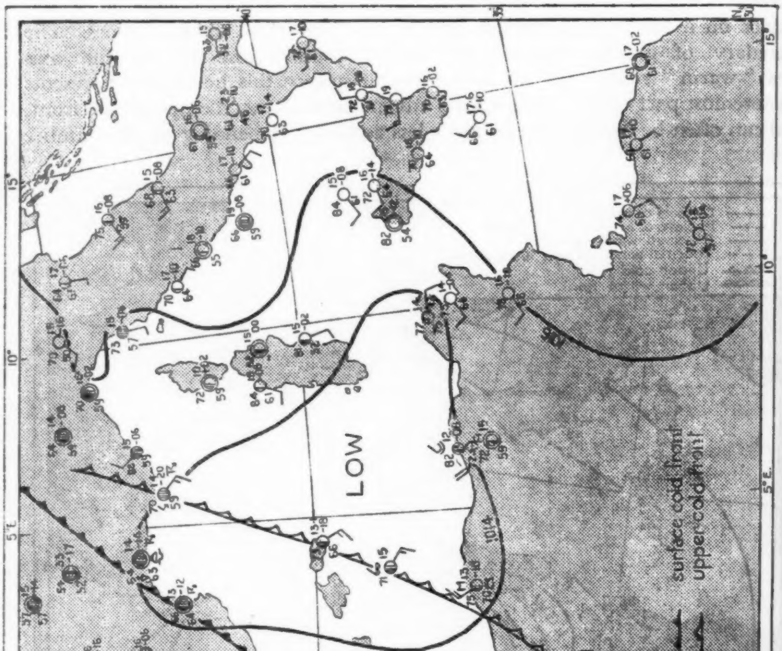

FIG. 3—SEA-LEVEL SYNOPTIC CHART, 0300 G.M.T., AUGUST 18, 1948

FIG. 3—SEA-LEVEL SYNOPTIC CHART, 0300 G.M.T., AUGUST 18, 1948

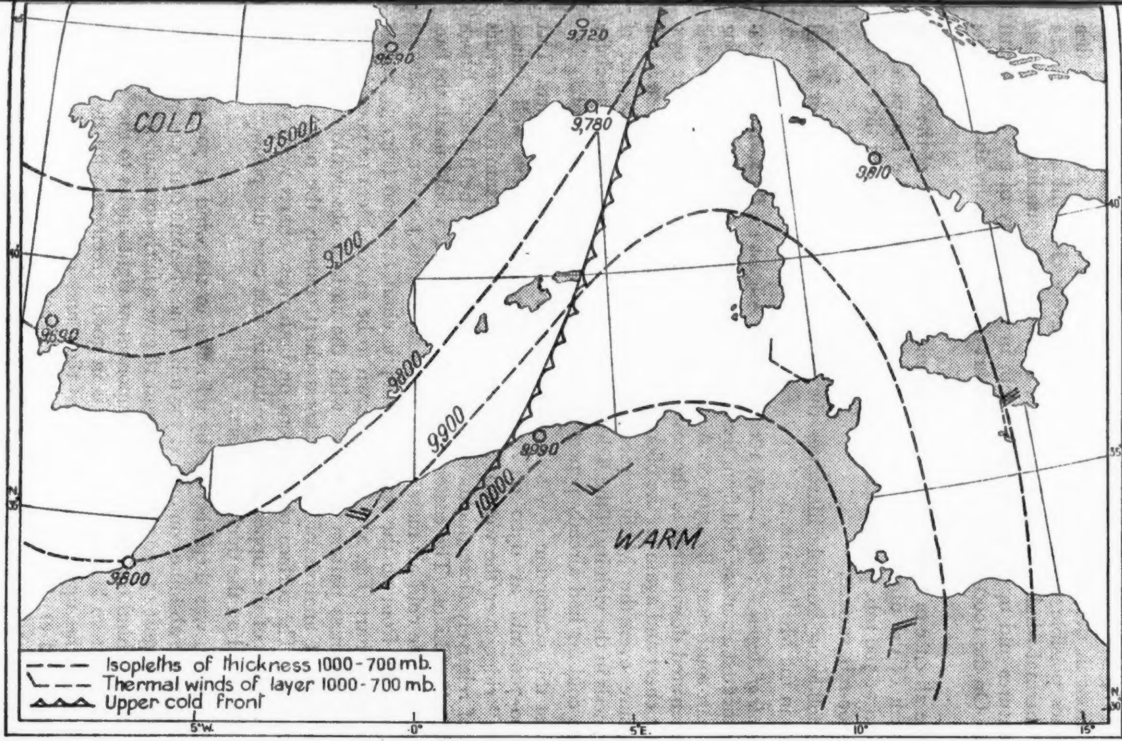

FIG. 4—THICKNESS LINES AND THERMAL WINDS OF THE LAYER 1000–700 MB., 0300 G.M.T., AUGUST 18, 1948

Heights are given in feet

illustrated on p. 191, in the Mediterranean this component may be large in the layer from the surface up to 5,000 ft. and mask the normal relationship between thickness lines and cold frontal surfaces. However, for many upper cold fronts in the Mediterranean the component of the thermal wind perpendicular to the front in the layer from the surface up to 700 mb. is small. It is then sometimes possible to detect the belt of relatively close thickness lines and strong thermal winds, provided there are a few reliable soundings of upper air temperatures and upper winds to 700 mb. in the vicinity of the cold frontal surface. On the 1000–700-mb. thickness chart this belt is usually about 100 miles wide.

In the absence of upper wind measurements in the vicinity of the front, the movement of the upper front can be estimated by taking the component of the wind at 700 mb. perpendicular to the front, as deduced from the contours of the 700-mb. surface.

The following example illustrates the value of thickness lines for frontal analysis in the Mediterranean.

Example of August 18, 1948.—At 1800 G.M.T. on August 17, the surface observations indicated a surface cold front from west Germany to east Spain advancing slowly east-south-east. By 0300 on August 18 (see Fig. 3), the cold air had still not penetrated downwards to the east coastal stations of Spain. On the 0300 synoptic chart and again on the 0600 chart there was evidence of a general fall of pressure over the Mediterranean between Spain and Sardinia and of cyclogenesis in the vicinity of the Balearic Islands. This suggested the possibility that the cold air had already penetrated the west Mediterranean aloft.

To test this assumption it was necessary to study the thickness charts. That for 1000–700 mb. at 0300 on August 18 (Fig. 4) shows a well defined "warm" ridge over the western Mediterranean. Careful examination reveals a belt of relatively close thickness lines from Morocco to the Balearic Islands to the Gulf of Lions. The eastern boundary of this belt would mark the foremost part of the cold air mass advancing aloft, and its position was drawn as an upper cold front on the sea-level synoptic chart for 0300 (Fig. 3), and on the thickness chart (Fig. 4). It was drawn to be as consistent as possible both with the thickness pattern and also with the surface observations available at the time of analysis of the thickness chart, namely the 0300 and 0600 observations. The surface observations on both these charts were very sparse in the vicinity of the upper front, so that in this case the position shown is primarily based on the thickness chart.

This position was then checked by reference to the wind at 700 mb. determined from the absolute contours at 700 mb. The absolute contours at 700 mb. for 1500 on August 17 and 0300 on August 18 gave a fairly constant wind of 240°, 40 kt. close behind the front. The component at right angles to the front was therefore about 20 kt., and this speed is in good agreement with the distance travelled by the upper front between 1800 and 0300, assuming the 0300 position, found as described above, to be correct.

Subsequent charts gave ever increasing confirmation of the existence of the front, and by 2100 it could be traced quite easily on the sea-level synoptic chart (Fig. 5) by a trough extending from the depression over the Gulf of Genoa and an associated belt of thunderstorms over Tunisia and along the Italian coast.

The front passed through Malta as a weak upper cold front about 0500 on August 19. A comparison of the Malta soundings for 1500 on the 18th and 19th shows that the temperature up to 900 mb. had risen slightly, but had fallen above 800 mb. and especially between 830 and 730 mb. (about 6°F.). The upper front in the south was therefore probably about 4,000 ft.

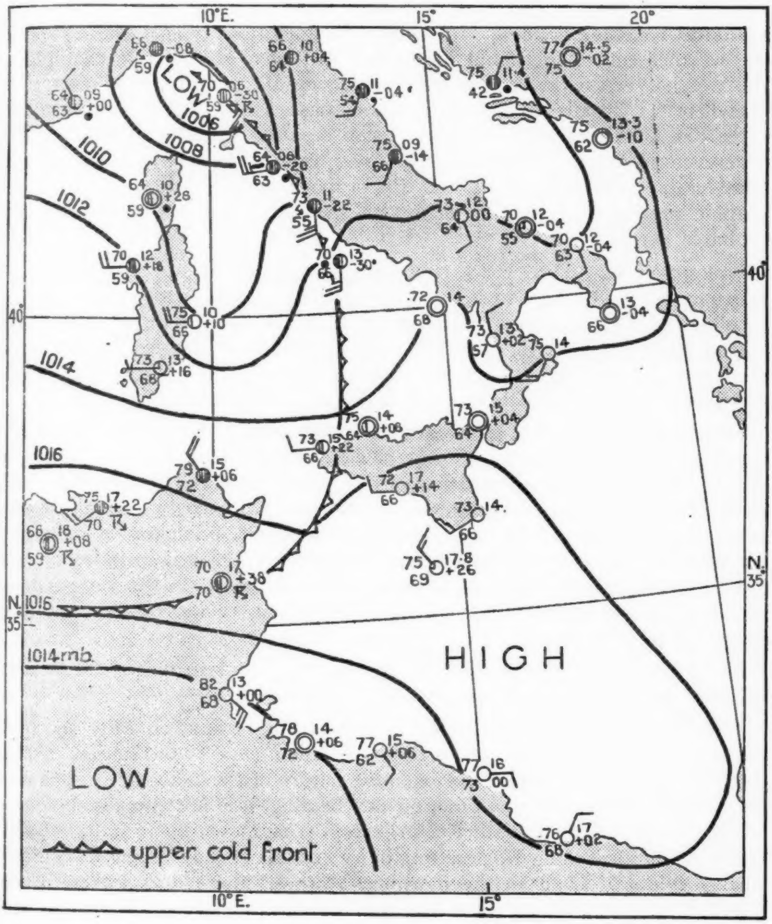

FIG. 5—SEA-LEVEL SYNOPTIC CHART, 2100 G.M.T., AUGUST 18, 1948

above sea level. Only in the extreme north, where cold air from the surface upwards had penetrated into the Mediterranean between the Alps and Pyrenees in the rear of the depression, was the front a typical surface cold front.

It should be noted that on the thickness charts it is the abrupt change of thickness gradient which is the essential characteristic of frontal surfaces.

For success in detection it is absolutely essential to resist the temptation to smooth out the thickness gradients. Rather should abrupt changes of thickness gradient be encouraged (within reason) to appear on the thickness charts.

RADAR WEATHER ECHOES

By R. F. JONES, B.A.

Part IV

Unusual weather echoes.—In the preceding sections typical photographs of the weather echoes in frontal situations have been given while examples of the weather echoes associated with cumulonimbus clouds have been given elsewhere[1*]. Usually the weather echoes observed conform broadly to the types described although, of course, each separate weather situation has its differences in detail. Occasionally, however, echoes are observed which depart considerably from the normal, and it is proposed in this section to give photographic examples of weather echoes of special interest together with their probable explanation.

Photograph (*a*).—This P.P.I. photograph was taken at 1014 G.M.T. on February 3, 1948, and shows, it is thought, the radar picture of a wave on a cold front. The synoptic charts, as given in the *Daily Weather Report*, show a cold front with waves extending east-north-east to west-south-west across south-east England and along the English Channel. Although this wave is not shown on the charts there seems little doubt of its existence.

The warm-front part of the wave to the north-east of the station† shows the characteristic diffuse edge, while the cold-front part to the north-west is more clearly defined and shows evidence of cellular structure. There is some fairly wide-spread precipitation in the warm sector as evidenced by the diffuse echo extending south-west from the station. Subsequent photographs show that the wave moved away eastwards, but the cold front trailed considerably and did not finally pass through the station until 1156 G.M.T. In the meantime the intensity of precipitation in the warm sector, as evidenced by the radar, increased considerably.

The photograph illustrates once more how the finer structure of the weather situation can be deduced with the help of radar.

Photograph (*b*).—This photograph, taken at 0850 G.M.T. on May 29, 1948, shows an unusually homogeneous response which, close to the station, extends to above 20,000 ft. Despite the extensive nature of the echo the precipitation reaching the ground at this time, on this bearing, was not composed of large enough drops to give a weather echo (except possibly within 10 miles) and the bright-band effect indicating melting of ice crystals at the freezing level is only weakly evident. Later in the morning, however, the echoes increased considerably in intensity and there was considerable rain over a wide area. It is thought that the echoes were received from large ice crystals which had grown to the requisite size to give a radar echo during their very slow descent against a wide-spread and fairly uniform upward current. The weak nature of the bright-band effect suggests that the ice crystals have only just reached the height of the freezing level on their descent. The echoes therefore suggest the existence of convergence taking place over a wide area and may therefore

*The index numbers refer to the list of references on p. 200.

†" Station " means East Hill, about 2 miles north-east of Dunstable, Bedfordshire.

have been the first warning of the wide-spread rain which developed later. The synoptic chart showed the presence of a depression in the extreme north of France moving eastwards but without any front to account for the rain.

The interpretation of the echoes is further confirmed by the report of a pilot who made an ascent at 0940 G.M.T. in the West Raynham area. He reported a continuous sheet of thin cloud from 6,000 ft. to " top not reached " at 29,000 ft. Throughout the ascent the sun was visible and conditions were quite smooth with no icing.

Photograph (*c*).—This H.R.T. photograph, taken at 1515 G.M.T. on July 4, 1949, on a bearing of 68° true, shows the response from precipitation falling from alto-cumulus castellatus cloud. At a height of 10,500 ft. in the column will be seen a brighter patch which is the " bright band " already referred to elsewhere. This patch indicates that the response from above 10,500 ft. comes from large ice crystals or snow-flakes. It will be seen that the echo decreases in extent and intensity below about 18,000 ft. and almost vanishes at 12,000 ft. This effect suggests that the base of the cloud was at about 18,000 ft. and that evaporation was taking place in the drier air beneath with a reduction in size of the snow-flakes or ice crystals and a consequent decrease in echo intensity. The ice crystals did not evaporate completely, however, and the echo increased again at 10,500 ft. as the ice crystals melted. Beneath 10,500 ft. the response was from rain and the increase in intensity again from about 6,000 ft. downwards suggests that the raindrop size was increasing in the lowest layers, probably by coalescence as the larger drops swept up the smaller in their path.

A further effect visible is the bending of the response caused by the increase of wind with height. The Downham Market upper wind at 1500 G.M.T. was constant in speed and direction at 248° true 36 kt. from 22,000 to 17,000 ft., and it will be seen that between these heights the echo column is vertical. From 17,000 to 10,000 ft. the wind decreased from 36 kt. to 25 kt., the direction remaining constant. The photograph was taken along the direction of the wind, and therefore shows the true effect of the wind increase with height. In falling from 17,000 to 10,000 ft. the echo column is displaced about 2 miles; the mean wind in this interval of height is $5\frac{1}{2}$ kt. (about 6 m.p.h.) less than the wind at 17,000 ft. and it follows that the snow-flakes or ice crystals took 20 minutes to fall from 17,000 to 10,000 ft. which gives a mean rate of fall of $1\frac{3}{4}$ m./sec. This rate of fall is in agreement with measurements made of the terminal velocity of large snow-flakes[2].

It would be expected that from 10,000 to 3,000 ft., where the precipitation was raindrops, the increased terminal velocity of the raindrops over that of the snow-flakes from which they were formed would be reflected in a more vertical column of echo, if the increase of wind with height was similar to the conditions above 10,000 ft. Although a change in inclination of the column to the vertical below the bright band is usually observed it is not so in this case. The deduced rate of fall of the raindrops is again of the order of 2 m./sec., and the only explanation can be that the fall of the raindrops was retarded by a considerable up current (of the order of 4 m./sec.) over a large interval of height. Examination of the radio-sonde ascent for this time (Downham Market 1500 G.M.T.) shows that, although the air was too dry to form cloud, convection currents could have occurred extending up to a height of about 7,000 ft. The existence of such an up current below 7,000 ft. may explain the increase in echo intensity in this interval by making coalescence of the raindrops more likely.

Photograph (*d*).—This is a photograph taken at about the same time (within 5 minutes) as photograph (*c*), and shows the type of cloud and precipitation from the cloud which gives the radar echo seen in photograph (*c*). It is almost certain that the cloud seen in the centre of this photograph is the one from which the radar echo of photograph (*c*), was received.

Photograph (*e*).—This photograph was taken at 1605 G.M.T. on July 28, 1948, on a bearing of 340° true, and shows the echo from an isolated thunderstorm which developed in conditions of exceptionally high surface temperature (over 90°F.) with little other cloud development for many miles around. The echo is unusually narrow (about 3–4 miles at its widest part) for a column of such great vertical extent—about 41,500 ft.—and suggests that the storm contained a single strong vertical current of air extending as far as the tropopause, instead of a number of up and down currents over a greater horizontal area which is usually the case in storms of such vertical extent.

Photograph (*f*).—This photograph was taken at 1234 G.M.T. on a bearing of 74° true during the thunderstorms of June 27, 1947, which were referred to by Douglas and Lewis[3].

The tendency for a bright band at 10,000–13,000 ft. in the echo nearest to the station is considered an indication of degeneracy in the storm close to the station with a reduction of the up currents to a very small value or perhaps to zero. The storm at 55–60-miles range is almost certainly the most active at this time.

REFERENCES

1. JONES, R. F.; Radar observation of heavy rain. *Nature, London*, **163**, 1949, p. 728.
2. HOOPER, J. E. N. and KIPPAX, A. A.; Interim report on measurements of radar echo from rain and snow. *T.R.E. Report No. T 2082*. Typescript, Malvern, 1947.
3. DOUGLAS, C. K. M. and LEWIS, L. F.; Thunderstorm of June 27, 1947. *Met. Mag., London*, **76**, 1947, p. 179.

METEOROLOGICAL RESEARCH COMMITTEE

The 59th meeting of the Committee was held on March 23. Reports from chairmen of the various sub-committees were received and the Research Programme for the forthcoming 12 months was approved. The Annual Report to the Secretary of State for Air was agreed.

The eighth meeting of the Instruments Sub-Committee was held on April 20. The papers considered included one by Mr. Grant[1] which describes the design of an aircraft thermometer with a very small lag. The solar radiation and lag errors of radio-sonde measurements were also discussed.

The ninth meeting of the Synoptic and Dynamical Sub-Committee of the Meteorological Research Committee was held in the Napier Shaw Laboratory at Dunstable on May 18, 1950. Members took this opportunity of viewing these new buildings and the work of the Forecast Research Division.

A paper by Mr. J. S. Sawyer[2] (" The formation and behaviour of cold-front waves ", giving the results of an investigation on wave disturbances on cold fronts, was discussed.

It was decided that the tephigram at present in use in the Meteorological Office should be modified to include the saturated adiabatics for condensation to supercooled water at temperatures below 0°C.

[1] *Met. Res. Pap., London*, No. 542, 1950. [2] *Met. Res. Pap., London*, No. 553, 1950.

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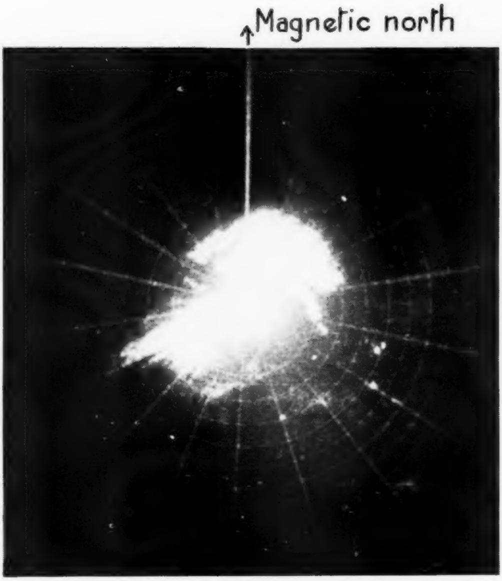

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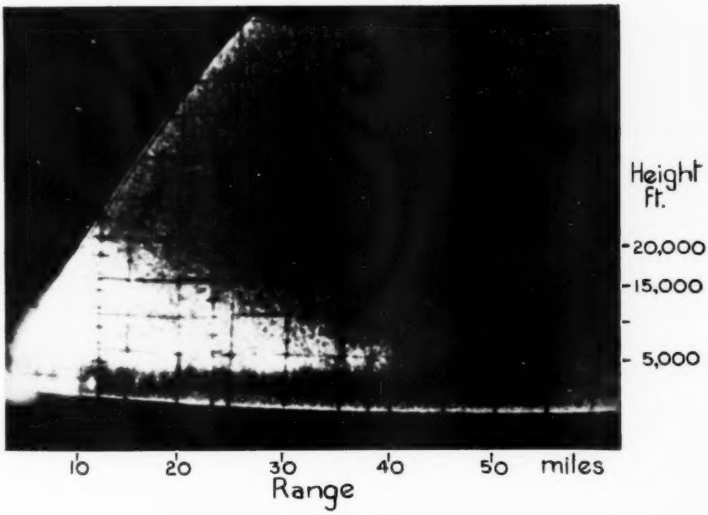
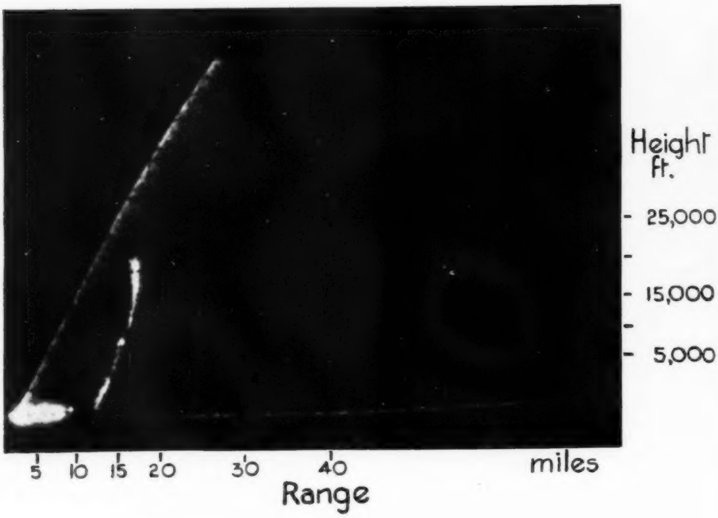


(*b*)

UNUSUAL RADAR WEATHER ECHOES

(see p. 198)



(c)

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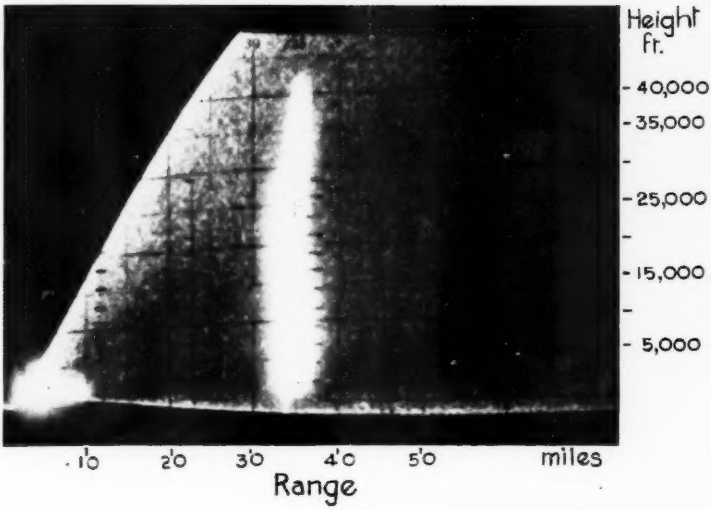
UNUSUAL RADAR WEATHER ECHOES

(see p. 198)



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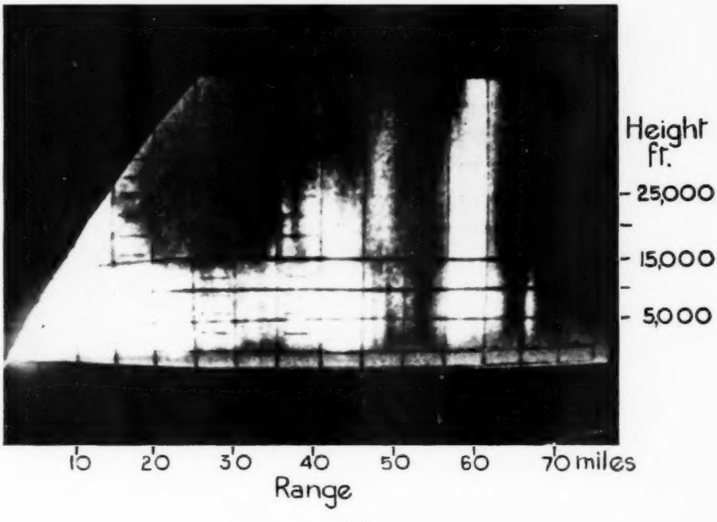

(f)

UNUSUAL RADAR WEATHER ECHOES

(see p. 198)

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CUMULUS CLOUD FROM A FIRE

Column of smoke which produced a radar echo
(see p. 207)

Other matters discussed were jet streams, the variation of wind in short periods of time and over short distances, and the forecasting of winds at great heights over Empire air routes.

ROYAL METEOROLOGICAL SOCIETY

Three further reports on the symposia held at Oxford in late March are included in this number (see also *Meteorological Magazine* for June 1950, p. 173).

March 28, 1950, 3.30–5.30 p.m.: Radiation and its effect on the troposphere and lower stratosphere. Chairman—Sir Robert Watson-Watt.

Prof. A. Adel (Arizona State College, United States) opened with a paper entitled " The emission spectra of the earth's surface, the troposphere and the lower stratosphere ". From measurements of the emission spectra of the earth's surface in wave-lengths between 4μ and 14μ and the absorption spectra of the atmosphere over a similar range of wave-lengths he deduced that while the effective radiation temperature of the nitrous oxide in the atmosphere varies between 32°F. and 50°F., that of the ozone varies between –27°F. and -51°F., *i.e.* the nitrous oxide is concentrated mainly in the lower troposphere while the ozone is much higher.

Prof. T. G. Cowling (Leeds University) then presented a paper on " Calculating temperature effects due to radiation ". He said that, although much information was still needed about the absorption coefficients of the various atmospheric gases and their variation with temperature and pressure, he found that the results of calculations made with various different assumptions as to the missing information varied surprisingly little. He had applied his method to a few special cases, such as the discontinuity at the tropopause.

Mr. R. Goody (Cambridge University) spoke on " The experimental determination of the thermal state of the lower stratosphere ". He described recent experiments in the measurement of the infra-red spectrum of the sun from a high-flying aircraft, and gave some preliminary results on the water-vapour content of the lower stratosphere using this method. He also discussed the possibility of making total radiation flux measurements, and showed that such measurements would probably be difficult to make with the desirable precision. Lastly, he considered the possibility of measuring the turbulent-heat transfer in this region and discussed various indirect methods of obtaining the information required.

Dr. G. D. Robinson showed several examples of the use of the Elsasser radiation chart as modified at Kew over the lowest 50 cm. of atmosphere and over the layer down to a pressure of 500 mb. He found that the radiation effect in the lower 50 cm. on some occasions would give rise to a temperature change of ten to thirty times that actually observed.

Dr. T. W. Wormell (Cambridge University) confirmed the presence of nitrous oxide in the lower atmosphere.

Mr. A. W. Brewer (Oxford University) emphasised that, considering the atmosphere as a heat engine, the cold " sink " must be at lower pressure as well as at lower temperature than the hot " source ", so that the cold " sink " must reside in the upper atmosphere. The upper troposphere must therefore be cooling (by radiation) at an average rate of about 1°C. per day.

There was further discussion about the radiation chart and the desirability of having a simple and reliable means of estimating the radiational heating or cooling in the upper air that can be applied regularly in synoptic practice.

March 29, 1950, 2.30–6.30 p.m.: The structure of weather systems. Chairman—Dr. R. C. Sutcliffe.

A major controversy in this informative discussion was the relative importance of heating effects and of mechanical processes in the development of weather systems.

Dr. W. Bleeker (Netherlands Meteorological Institute) maintained that the jet stream was the result of differential heating, *e.g.* at the boundary between warm sea and cold continent. He showed, by means of simple diagrams, that the circulation arising from unequal heating at the surface caused a strong thermal gradient in the constant-pressure surfaces up above (at about 200 mb.), the temperature being lowest over the heated air and highest over the unheated. It was there, on the cold side of the upper boundary between the two air masses, that jet streams developed. The development was greatest where one circulation system reinforced another; indeed, secondary cold fronts were characteristic of all examples discussed by Durst and Davis[1]* and Palmén[2].

Dr. A. Nyberg (Swedish Meteorological Institute) said that the interaction of one circulation system on another was a factor in an empirical approach to forecasting frontogenesis; other factors were the slope and intensity of existing fronts. He had considered that the region of instability on the south side of a jet stream would have been a " breeding ground " for depressions; but, in the illustration shown (November 7–10, 1948), the jet stream appeared as the result, not the cause, of frontogenesis. In forecasting, one needed chiefly to be on the watch for areas of confluence.

Dr. W. L. Godson (Canadian Meteorological Service) stressed the necessity for upper air analyses and described the use of charts of frontal contours. These, drawn at intervals of 100 or 200 mb., are part of the forecasting routine of the Canadian Meteorological Service. He stated also that a double frontal system was necessary for intense cyclonic development. This was confirmed in the charts used for illustration: the two main depressions over North America at 1500 G.M.T., January 5, 1949, were each associated with waves, in phase, on the arctic and polar fronts.

With reference to the use of thickness charts, *Mr. J. S. Sawyer* showed from charts for May 1948, that Sutcliffe's formulae[3] for thermal development and thermal steering did, in fact, express what happened in the atmosphere. *Major Bundgaard* (United States Air Weather Service) referred to the forecasting of 24-hr. thickness by separate extrapolation of advective and non-advective components. These, *Mr. J. M. Craddock* had found to be negatively correlated.

Mr. A. G. Matthewman affirmed that cold air heated over the sea assisted the formation of depressions. This was confirmed by charts of the percentage frequency of cyclogenesis, 1899–1939, shown by *Dr. S. Petterssen* (United States Air Weather Service). In these, a zonal pattern was manifest, modified by local influences of sea surface and snow cover.

Prof. C. G. Rossby (University of Chicago) asserted that, in short-term changes, mechanical processes were more important than thermal, although the ultimate cause was thermal. His argument that jet streams did not always occur over

*The index figures refer to the list of references on p. 203.

regions of differential heating was countered by *Dr. Bleeker's* statement that transport of air in the lower layers frequently caused such displacement. *Dr. R. C. Sutcliffe* favoured Prof. Rossby's point of view.

REFERENCES

1. DURST, C. S. and DAVIS, N. E.; Jet streams and their importance to air navigation. *J. Inst. Navig., London*, **2**, 1949, p. 210.
2. PALMÉN, E.; On the distribution of temperature and wind in the upper westerlies. *J. Met., Lancaster Pa.*, **5**, 1948, p. 20.
3. SUTCLIFFE, R. C.; A contribution to the problem of development. *Quart. J. R. met. Soc., London*, **73**, 1947, p. 370.

March 31, 1950, 9.30–12.30: Meteorology and the community. Chairman—Sir Robert Watson-Watt.

The opening speakers in this, the final symposium, were Sir Nelson K. Johnson, Sir David Brunt, Sir William G. Ogg, and Mr. N. R. Hagen (who deputised for Dr. Reichelderfer).

Although forecasting came in for some mention—one liked especially the reference to the 30-day forecasts in the United States which " were not published, though we allow the public to buy them "—the interesting, perhaps encouraging, fact was the attention to other applications of meteorology, and the indications of other fields to explore. Thus there was the work of the Meteorological Office in hydrology, which the *Director* was confident would soon become increasingly important to the national economy, and its active study of the weather problems of agriculture. With some apt examples, *Sir David Brunt* showed how the meteorologist's knowledge could have a decisive influence in the engineer's work—his remarks on smoke pollution being later underlined by *Dr. Sutton*—and called for a pioneering spirit among meteorologists to look for these applications and work on them.

Sir William G. Ogg (Rothamsted) led the speakers on " Weather and food " and called for a wider study of biological meteorology as a major contribution to agricultural production. Contributors on this theme were *Dr. Petersen* (Denmark) and *Mr. Simmers* (New Zealand) whilst *Dr. Penman* (Rothamsted) made a spirited appeal to physicists to come into work on agricultural meteorology, and to meteorologists to make sure they were getting the observations they wanted and no more.

Cdr. Frankcom was the voice of the mariner and described the effects of weather on the design and safety of shipping and the care of their cargoes.

On the subject of selling meteorology to the user interests, *Cdr. Hogben* called for meteorological " bagmen " to explore the industrial field generally—as the Meteorological Office was doing in agriculture—for applications of the knowledge we already had—not necessarily only from the forecast angle, but for planning applications. And *Mr. A. H. Yates* (College of Aeronautics, Cranfield) wanted a quick resumption of AIRMET as the best method of getting up-to-date weather information over to a variety of users.

All these contributions made one realise the need for bigger and better meteorological services to allow as much concentration on industrial and other problems as has been given to aviation. And if one wondered where the money was coming from, Mr. Hagen and Mr. Saunders had an answer—"Show the business man that you can save him money and you'll get his support ".

MEETING OF THE CHALLENGER SOCIETY

At the 167th scientific meeting of the *Challenger* Society, held in London on April 19, a paper of exceptional interest " Problems and new techniques for the present-day oceanographer " was read by Mr. C. O'D. Iselin, Director of the Woods Hole Oceanographical Institution, Massachusetts, United States. The good work of the Woods Hole Institution is well known, and the paper aptly illustrates the wide range of activities upon which American oceanographers are engaged.

Mr. Iselin's paper was solely concerned with the North Atlantic, and discussed such items as the distribution in depth of the 10°C. isotherm; the vagaries of the Gulf Stream, both at the surface and in depth, and a section through its temperature profile; the practical use of the bathythermograph; the practical value of " Loran " to the oceanographer, particularly when obtaining details of surface current movement; an ingenious electro-magnetic method of obtaining ocean-current observations from a moving ship; and experiments with sonic waves of various frequencies to determine the nature of " layer " echoes at varying depths in the water of the oceans.

Although he did not mention meteorology as such, Mr. Iselin's paper did much to emphasise the intimate and inescapable relationship between meteorology and oceanography, and indeed of the necessity of those engaged upon these two sciences getting together and generally co-operating. The contours of the 10°C. isotherm, for example, followed in a remarkable way the track of the Gulf Stream and North Atlantic Drift at the surface—thus showing that the warming effect of the Gulf Stream is effectual at considerable depths, and that there is perhaps also a similar drift effect across the ocean at such depths. This fact is undoubtedly of great meteorological importance. Another striking feature was the curious waves or swirls which have been shown to occur in the southern extremity of the Gulf Stream. These swirls have been investigated by the Woods Hole Institution in considerable detail, and it seems that they are, to some extent, analagous to the waves which occur at frontal " meeting places " in the atmosphere near the earth's surface. The whole thermal structure of the oceans and particularly its intricate pattern at the edge of the Gulf Stream was vividly described in slides, and this also seems to be of considerable meteorological interest for it is certain that the vagaries in the ocean temperature have very great effect upon the overlying atmosphere.

There seems little doubt that the use of electronic aids to navigation (" Loran " in this case) is an enormous boon to the oceanographer, who can thus obtain regular " fixes " quite irrespective of atmospheric conditions, and enable very accurate ocean-current observations to be made merely by letting the ship steam a steady course at slow speed. The electro-magnetic apparatus which Mr. Iselin referred to is towed astern of the ship and depends broadly for its action upon the magnetic force of the earth and the currents induced in sea water flowing across or along the magnetic field; if there is no ocean current present, then there is no electrical disturbance on the instrument. To operate the instrument a ship needs to steer various courses so as to steam across the current in order to get its maximum effect. The sonic sounding experiments showed that many of the false echoes which appeared on the trace are due to living organisms of some kind or other in the water, and that by varying the frequency of the transmission one can get echoes from different sizes of organisms.

C. E. N. FRANKCOM

LETTER TO THE EDITOR

Unusual fall of rain at Upavon on November 4, 1949

During the afternoon of November 4, 1949, an outbreak of rain occurred at Upavon. Evidence available suggests that this rain fell from a layer of stratocumulus, the top of which was at a temperature above the freezing point. Such rainfall is comparatively rare, at least in temperate latitudes.

The 1200 G.M.T. synoptic chart showed that the Upavon area was in warm air, a warm front lying well to the north across the north Midlands and central Ireland. The morning ascents at Larkhill and Camborne suggested that a sheet of stratocumulus would spread across south England during the day. The cloud sheet reached Upavon about noon with the base estimated at 1,800 ft. above station level. It was anticipated that any precipitation occurring at Upavon during the afternoon would be very slight and take the form of drizzle.

By 1400 it was evident that the stratocumulus to the south-west of the station was thickening and that the base was becoming lower. A balloon sent up shortly after 1400 indicated broken cloud at 1,200 ft., with the main layer at 1,500 ft. Visibility also fell from 6 miles at 1300 to 3 miles at the time of the balloon ascent. At 1450 approximately slight drizzle commenced, but within about five minutes this drizzle had turned to rain, which continued for nearly an hour, gradually turning to slight drizzle again at 1600.

There was no doubt that the precipitation was rain and not heavy drizzle—it first drew my attention beating up against the windows. The fall was sufficiently heavy for water to run off the roof and down the fall-pipes within five minutes of its commencement, and was splashing in the puddles in the road. Other members of the staff agreed that it was definitely rain that was falling.

At about 1520, when the rain was still falling steadily, W/Cdr. W. E. Gardiner, D.F.C., A.F.C., landed on the airfield in a Proctor aircraft, having flown from Abingdon. He telephoned the Meteorological Office almost immediately with the following report.

Over the airfield and surrounding districts there was an 8-eighths layer of stratocumulus, roll topped. He had been flying along the top of the layer and had been flying in and out of cloud between 5,500–5,800 ft. (heights above M.S.L.). This would give the cloud top over Upavon as between 4,920 and 5,220 ft. (Upavon is 580 ft. above M.S.L.). Above the stratocumulus there was 4 eighths of thin altocumulus, base unknown. The altocumulus was in large patches, mainly towards the west. No precipitation was experienced whilst flying in the cloud tops. The upper part of the stratocumulus cloud was very tenuous, the sun being visible when several hundred feet inside the cloud. There was no turbulence. Descending through the cloud sheet, drizzle was encountered between 3,000 ft. (above M.S.L.) and the base of the cloud which he gave as 1,500 ft. (above M.S.L.). Thus the layer in which precipitation occurred was between 2,420 and 920 ft. above Upavon. The cloud between these levels was much denser than higher up, and there was marked turbulence. No temperatures were recorded.

The 1500 ascent from Larkhill (440 ft. above M.S.L.), situated 5 miles south-west of Upavon, showed that, in the general south-westerly current prevailing, the balloon must have been near Upavon during its ascent and there appears to be little reason for supposing that the ascent was not representative of the

conditions in the Upavon area about the same time. The ascent indicated that the top of the stratocumulus layer was at 850 mb. (4,678 ft. above Larkhill) whilst the freezing level was at 6,238 ft. The presence of thin altocumulus was also indicated at about 750 mb. The dew-point curve suggested that precipitation was unlikely to occur from this medium layer.

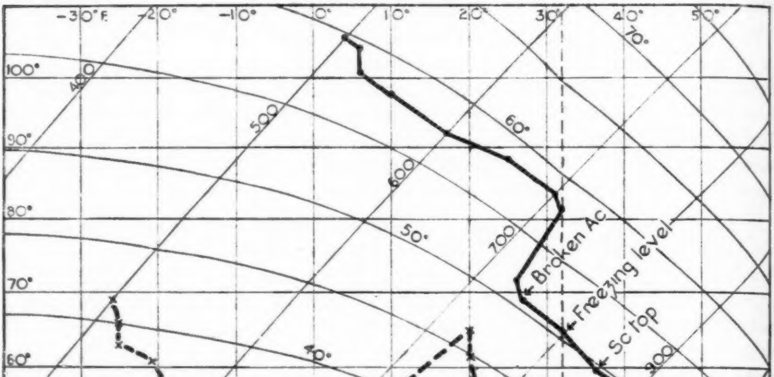

FIG. 1—RADIO-SONDE ASCENT FROM LARKHILL, 1500 G.M.T., NOVEMBER 4, 1949

There seems little reason to expect a large variation in freezing level over the distance between Larkhill and Upavon, and allowing for the difference in heights the freezing level at Upavon was about 6,100 ft., almost 1,000 ft. higher than the top of the cloud layer. The presence of ice crystals in the cloud was therefore impossible. It seems therefore that the rain that fell was the result of the coalescence of small water-drops in the lower part of the cloud. The fact that turbulence was in this part only may be significant.

The rainfall was very local. A check was made on surrounding stations but, with the exception of Netheravon, 3 miles south of Upavon, no precipitation had occurred up to 1600. At 1600 Boscombe Down, 10 miles to the south, reported intermittent slight drizzle. The lowering of the base of the stratocumulus cloud was generally remarked upon.

Upavon, Wiltshire, November 17, 1949 E. J. KINSHOTT

NOTES AND NEWS

Ocean weather station JIG—a joint Anglo-Dutch station

On April 15, 1950, the Netherlands' ocean weather ship *Cumulus* took over duty from the British *Weather Recorder* at station JIG, lat. 52°30'N., 20°00'W.;

this is the first occasion British vessels have shared the operation of an ocean weather station with one of another nationality. *Cumulus* will perform five 21-day periods of duty at JIG in 1950 thus doing alternate duties with three British ships which will be able to have well deserved " lay-up " periods.

While on duty *Cumulus* will carry out the same general meteorological and oceanographical procedure as her British colleagues, using the same radio channels to Dunstable and Prestwick though she will also communicate direct with Holland. R.A.F. aircraft will drop mails and carry out exercises as with the British ships.

Cumulus was originally a United States Navy frigate and is considerably bigger than the British vessels.

On the arrival of *Cumulus* at JIG her Master and crew were greeted with traditional maritime courtesies by the Master and crew of the *Weather Recorder*.

Radar echo from smoke

The photograph facing p. 201 of this Magazine shows a cumulus cloud produced by a fire of bales of cork at Hayes (Middlesex) on August 18, 1949. The photograph was taken by Mr. R. M. Poulter at 1400 G.M.T. looking south-south-east from Hillingdon, a distance of 2½ miles from the fire. This column of smoke produced the radar echo illustrated in the *Meteorological Magazine* for March 1950 (facing p. 80). The estimated height of the cloud top is 5,000 ft.

REVIEW

Electric charges on rime-covered surfaces. By C. Kramer. Koninklijk Nederlandsch Meteorologisch Instituut No. 102. Mededeelingen en Verhandelingen, Serie A, No. 54. 8vo, 9½in. × 6¾ in., pp. 128. *Illus.* 's Gravenhage, 1948. 3·00 florins. Dutch with English summary.

The importance of the work of Findeisen and Lange, published in the *Meteorologische Zeitschrift* between 1940 and 1943, on the electrical phenomena accompanying the growth, evaporation, and splintering of ice crystals is now becoming widely recognised. Dr. Kramer has repeated the German experiments but was not able to confirm them in all respects. The positive charging of a body upon which rime is being deposited was found by Kramer to cease as soon as the first uniformly oriented layer of crystals was deposited on the surface, and, during the subsequent further growth of the layer, it was found that the potential of the body decreased showing the development of a negative charge. Findeisen found a marked positive charge was produced when super-cooled water droplets froze on to ice crystals but Kramer obtained a negative charge. Kramer found the rate of charging of the body on which rime was being deposited to be proportional to the velocity of the air current, and a sudden increase in this velocity led to a strong positive increase in the potential. Kramer's experiments included efforts to detect complementary charges in the air, and these were found to have the right sign when sudden changes in the potential of the test body were made but were difficult to measure when the growth of the charge on the test body was gradual. Findeisen's observation that a growing layer of rime throws off negatively charged " splinters " was repeated with confirmation of the " splintering ". Relatively few of the splinters, however, were noticeably charged though most of those with appreciable charge were negative.

These effects are of great importance to the physics of cloud formation, since the " splinters " provide sublimation nuclei, as well as to the generation of electric charge in clouds, and meteorologists will be grateful to Dr. Kramer for his work in a subject in which the experimental difficulties are great.

G. A. BULL

METEOROLOGICAL OFFICE NEWS

Exploration.—The ships *William Scoresby* and *Discovery II*, under the direction of the newly formed National Institute of Oceanography, have now sailed on voyages of about two years' duration, the first to the Indian Ocean and the second to both the Indian Ocean and the Antarctic Ocean. In addition to making normal meteorological observations, the *Discovery II* will make cloud-height observations with " free " balloons.

Publicity.—An illustrated pamphlet with the title " Your Weather Service " is being published by the Central Office of Information with the object of bringing the activities of the Meteorological Office to the notice of the public. The book lays special emphasis on the services which the Office can provide for public bodies and private individuals in both the forecasting and climatological fields. There is also a useful section on the interpretation of weather forecasts.

Assistance to farmers.—Detailed information about recent weather can sometimes be of as much value to the farmer as forecasts of future weather. For example, if potatoes are sprayed within a week of a period of continuously warm and humid weather, the spread of potato blight can be controlled or even prevented. For this reason arrangements have recently been made in consultation with the Plant Pathology Laboratory of the Ministry of Agriculture by which the Meteorological Office issues warnings whenever the conditions which are believed to lead to blight have occurred.

To provide agricultural scientists with a brief summary of current weather, the Meteorological Office has also begun to issue a weekly weather summary to about 300 officers of the National Agricultural Advisory Service. The summary gives details of the weather each day, departures from average of the weekly sunshine, rainfall, air and soil temperatures and statistics of the rainfall as well as calculated losses of moisture by transpiration and also details of the incidence of frost. The summary is prepared for each of the eight " provinces " of the Ministry of Agriculture in England and Wales, and reaches recipients within a week of the period to which the summary refers.

Radio-sondes.—In the June number of this Magazine, reference was made to the trials at Payerne, Switzerland, of different types of radio-sonde instruments. The instruments compared were Finnish, German, French, Swiss, two types from the United States and the British. The personnel taking part also included delegates from Belgium, Holland, Norway and Sweden. Two or more different types of sonde were attached to the same balloon and corresponding readings of pressure, temperature and humidity were evaluated for each minute. In very favourable conditions it was found possible to launch six radio-sondes, one under the other, the lift being supplied by three balloons. Ascents were made at about 1500 and 2100 local time, and the same combination of sondes

used for each ascent on the same day in order to obtain information about the differences between day and night soundings. The results of the comparisons are now being worked out.

Helicopters.—Helicopters of British European Airways on the passenger service between Liverpool and Cardiff which started on June 1 fly without radio operators on board. In consequence, broadcasts by radio telegraphy of meteorological information cannot be received by the pilots while in the air. To cover the deficiency special arrangements have been made to provide meteorological information by radio telephony on request.

Radiation recording.—For some years, a programme of investigation into various methods of recording radiation has been carried out at Kew Observatory, and this programme is now being extended to other stations. One instrument for measuring total radiation on a horizontal surface and another for measuring the diffuse radiation from the whole sky, but not from the direct sun, are being supplied to Lerwick, Eskdalemuir, Aberporth and Mildenhall. These instruments are described in the *Meteorological Magazine* for February and March, 1936, and further details will be given in *Geophysical Memoirs* No. 86, to be published shortly. A simpler type of bimetallic radiation recorder is also being sent for trial to a number of stations.

Recruitment of assistants.—It is satisfactory to be able to report that there has been a good response to the intensified recruiting campaign referred to in the March number of this Magazine. Assistants serving at under-staffed units should shortly begin to feel the benefit of the new arrivals.

No small share of the credit for this happy result belongs to senior Meteorological officers and other officers-in-charge who helped by visiting local labour exchanges, youth employment offices and schools and by personal discussion with prospective candidates.

R.A.F.V.R. Meteorological Section.—Each member of the meteorological section of the R.A.F.V.R. is normally " affiliated " to a neighbouring R.A.F. station having a suitable meteorological office. Attendances for non-continuous training are then made on occasional evenings and at week-ends. Affiliations have now been completed. At one R.A.F. station near London where there are several reservists it has been possible to arrange attendances in such a way that all the meteorological work needed by the Royal Auxiliary Air Force Squadrons on the station is done by the reservists.

Central Forecasting Office, Dunstable.—A magazine entitled *Halcyon*, devoted to " gossip, news and jest about the folk at the Meteorological Office, Dunstable " has recently been started by the staff there. It is expected that five or six numbers will be issued each year. The latest number gives the office bearers of the Sport and Social Club for the current year. They are Mr. E. G. Bilham (Chairman), Dr. A. G. Forsdyke (Treasurer) and Mr. T. H. Clifton (Secretary).

Sports activities.—We would offer our congratulations to :—

Miss D. J. T. Ayres, on being chosen for the Civil Service hockey team ;

Mr. P. E. Hammerton, 16 years of age, on being chosen to play for the Civil Service Chess team against Combined Oxford and Cambridge Universities;

Mr. R. E. Farms on being runner-up in the scratch and handicap competition for the Air Ministry Golf Championship;

Mr. R. E. Farms and Mr. G. J. W. Oddie on being selected as two of a team of three to represent the Air Ministry in the Lloyd George Civil Service Golfing Cup and on winning both their matches;

Relay Team, Meteorological Office, Uxbridge, on winning the relay at Uxbridge Royal Air Force Sports;

Cpl. A. F. Lewis and L.A.C. D. A. Abott on being selected to play water polo for the R.A.F. during their recent London tour. Mr. Lewis, who holds two Air Ministry Swimming Championships, played in every match and was leading goal scorer during the tour.

NEWS IN BRIEF

The following award was announced in the Birthday Honours List, June, 1950 :—

C.B.E.

Professor O. G. Sutton, D.Sc., F.R.S.

BOOK RECEIVED

A revised analysis of solar-constant values, by C. G. Abbot. *Smithson. misc. Coll.,* **107,** No. 10. Size : 9½ in. × 6¼ in., pp. 9. *Illus.* Smithsonian Institution, Washington D.C. 1947.

WEATHER OF MAY 1950

Mean pressure was about 1020 mb. between Iceland and Norway, and over 1020 mb. south-westward of Vancouver Island. It was below 1010 mb. over most of Alaska, over Mexico and Arizona and in the Sahara. Deviations from the normal for May were generally small, but from southern Greenland eastwards to about longitude 0°, pressure was more than 5 mb. above normal, and it was above normal over an area extending from the eastern parts of the United States and Canada, across Greenland and the northern part of the North Atlantic to most of Europe and the central part of the Mediterranean.

In the British Isles the weather was very changeable with alternating cold and warm periods. It was dry on the whole but rainfall exceeded the average over much of an area extending south-east from the Wash to West Hampshire and locally in Devon and Cornwall.

During the opening days a large depression westward of Scotland moved north-east and turned east and became less deep; rain occurred generally on the 1st and showers and local thunderstorms on the 2nd. Thereafter, the Azores anticyclone spread north-east and mainly fair weather prevailed apart from slight showers locally in eastern districts of England on the 3rd and very slight scattered rainfall on the 4th. Subsequently a belt of high pressure extended south-south-west across the British Isles from an anticyclone over Scandinavia. Meanwhile a shallow depression moved slowly westward from Germany over England giving rain in England and Wales. On the 8th a small depression over Holland moved west-south-west and was associated with further rain in the southern half of England.

Thereafter, the Scandinavian anticyclone moved slowly south-west to a position off the north of Scotland and a spell of warm, sunny weather prevailed over the British Isles. Day temperatures reached or exceeded 70°F. at a number

of places, among the highest readings being 76°F. at Prestwick on the 11th, 78°F. at Prestwick and 76°F. at Eskdalemuir on the 12th and 77°F. at Valentia on the 13th. On the 13th a new anticyclone near Iceland moved slowly east and later south-east and the dry spell persisted over the British Isles until the 16th, but a rapid fall in temperature occurred on the 14th, with an influx of cold northerly winds of polar origin. On the 16th and 17th a cold front moved slowly south over Scotland and Ireland giving scattered rain or showers in these areas but weather continued dry over practically the whole of England.

A change of type occurred on the 19th when a small depression developed to the west of Portugal and subsequently moved quickly north-east across England to the North Sea. Rain occurred fairly generally and there were local thunderstorms. By the 21st pressure was high from south-west Iceland to Norway and a large depression was centred off south-west Ireland, while associated troughs of low pressure moved north over the British Isles. Heavy rain occurred in places and was accompanied locally by thunder and hail (2·21 in. at Hockliffe, Bedfordshire, and 2·10 in. at Battlesden Pumping Station, Bedfordshire). In Buckinghamshire a tornado moving from Wendover to Linslade caused great damage. Trees were felled and vehicles in farmyards and tiled roofs of old buildings were lifted. There was also heavy rain and flooding and large hailstones; the largest individual stone, an irregular mass of ice with several centres, measured $6\frac{1}{2}$ in. round. Subsequently, the depression off south-west Ireland drifted slowly south-west, while the anticyclone west of Iceland moved south and by the 24th the cold north to north-east winds over Scotland reached the south of England. From the 22nd to the 23rd rain occurred, chiefly in the south-west, and was heavy in places. On the 24th and 25th the depression, now centred north-west of Portugal, moved slowly east and later moved north-east to north France; further rain occurred in England, particularly in the south (1·97 in. at Torquay and 1·57 in. at Guernsey). On the 26th and 27th a depression centred over the south of Iceland moved south-east to the North Sea and on the 28th and 29th another disturbance over south Iceland moved east-south-east. Meanwhile, the Azores anticyclone spread east. Rain, mainly slight, occurred in many places on the 26th and 27th and further rain fell in the west and north on the 28th and 29th. On the closing days anticyclonic conditions prevailed and temperature rose again reaching or exceeding 70°F. at a number of places in England.

The general character of the weather is shown by the following provisional figures :—

	Air Temperature			Rainfall		Sunshine
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average
	°F.	°F.	°F.	%		%
England and Wales ..	81	27	+0·1	90	−2	93
Scotland	80	23	+0·6	66	−3	107
Northern Ireland ..	75	32	+0·9	54	−6	119

RAINFALL OF MAY 1950

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square ..	1·42	81	*Glam.*	Cardiff, Penylan ..	2·10	86
Kent	Folkestone, Cherry Gdn.	1·28	76	*Pemb.*	St. Ann's Head ..	1·39	69
,,	Edenbridge, Falconhurst	1·61	87	*Card.*	Aberystwyth	1·33	64
Sussex	Compton, Compton Ho.	1·45	65	*Radnor*	Tyrmynydd	1·73	50
,,	Worthing, Beach Ho.Pk.	1·06	64	*Mont.*	Lake Vyrnwy	1·73	54
Hants	Ventnor, Roy. Nat. Hos.	1·74	102	*Mer.*	Blaenau Festiniog ..	2·20	39
,,	Bournemouth	1·90	108	*Carn.*	Llandudno	·50	28
,,	Sherborne St. John ..	1·33	69	*Angl.*	Llanerchymedd ..	·74	31
Herts.	Royston, Therfield Rec.	2·40	124	*I. Man.*	Douglas, Borough Cem.	1·17	47
Bucks.	Slough, Upton	1·71	102	*Wigtown*	Port William, Monreith	1·77	75
Oxford	Oxford, Radcliffe ..	2·19	117	*Dumf.*	Dumfries, Crichton R.I.	1·98	72
N'hant.	Wellingboro', Swanspool	3·16	163	,,	Eskdalemuir Obsy. ..	2·26	68
Essex	Shoeburyness	2·03	156	*Roxb.*	Kelso, Floors	1·19	62
,,	Dovercourt	1·40	101	*Peebles*	Stobo Castle	1·82	80
Suffolk	Lowestoft Sec. School ..	2·17	135	*Berwick*	Marchmont House ..	1·55	63
,,	Bury St. Ed., Westley H.	2·41	132	*E. Loth.*	North Berwick Res. ..	1·66	83
Norfolk	Sandringham Ho. Gdns.	2·14	117	*Midl'n.*	Edinburgh, Blackf'd. H.	1·89	92
Wilts.	Bishops Cannings ..	2·30	118	*Lanark*	Hamilton W. W., T'nhill	1·55	65
Dorset	Creech Grange.. ..	1·69	83	*Ayr*	Colmonell, Knockdolian	1·95	79
,,	Beaminster, East St. ..	1·55	75	,,	Glen Afton, Ayr San ..	1·82	61
Devon	Teignmouth, Den Gdns.	3·98	218	*Bute*	Rothesay, Ardencraig	1·44	40
,,	Cullompton	1·99	92	*Argyll*	L. Sunart, Glenborrodale	2·91	82
,,	Ilfracombe	1·52	74	,,	Poltalloch	1·91	66
,,	Okehampton, Uplands	3·08	115	,,	Inveraray Castle ..	2·52	64
Cornwall	Bude, School House ..	2·00	109	,,	Islay, Eallabus ..	2·75	104
,,	Penzance, Morrab Gdns.	2·35	106	,,	Tiree	1·26	50
,,	St. Austell	2·15	89	*Kinross*	Loch Leven Sluice ..	1·89	77
,,	Scilly, Tresco Abbey ..	2·31	137	*Fife*	Leuchars Airfield ..	1·91	98
Glos.	Cirencester	2·78	135	*Perth*	Loch Dhu	2·53	50
Salop.	Church Stretton ..	1·43	56	,,	Crieff, Strathearn Hyd.	1·46	59
,,	Cheswardine Hall ..	1·27	57	,,	Pitlochry, Fincastle ..	1·49	79
Worcs.	Malvern, Free Library	2·19	101	*Angus*	Montrose, Sunnyside ..	1·31	64
Warwick	Birmingham, Edgbaston	1·61	75	*Aberd.*	Braemar	1·43	60
Leics.	Thornton Reservoir ..	1·85	92	,,	Dyce, Craibstone ..	1·44	56
Lincs.	Boston, Skirbeck ..	3·36	191	,,	Fyvie Castle	1·62	63
,,	Skegness, Marine Gdns.			*Moray*	Gordon Castle	·83	39
Notts.	Mansfield, Carr Bank ..	1·67	79	*Nairn*	Nairn, Achareidh ..	2·17	122
Derby	Buxton, Terrace Slopes	1·56	50	*Inverness*	Loch Ness, Garthbeg ..	1·33	53
Ches.	Bidston Observatory ..	·72	38	,,	Glenquoich	3·79	69
Lancs.	Manchester, Whit. Park	1·46	69	,,	Fort William, Teviot ..	2·87	73
,,	Stonyhurst College ..	1·52	53	,,	Skye, Duntuilm ..	1·96	69
,,	Squires Gate	·93	45	*R. & C.*	Tain, Tarlogie House ..	1·82	88
Yorks.	Wakefield, Clarence Pk.	2·13	108	,,	Inverbroom, Glackour..	1·35	45
,,	Hull, Pearson Park ..	2·29	119	,,	Applecross Gardens ..	1·57	49
,,	Felixkirk, Mt. St. John	1·10	58	,,	Achnashellach	2·06	49
,,	York Museum	1·69	85	,,	Stornoway Airfield ..	·98	40
,,	Scarborough	1·62	85	*Suth.*	Loch More, Achfary ..	3·47	79
,,	Middlesbrough.. ..	1·40	73	*Caith.*	Wick Airfield	1·72	55
,,	Baldersdale, Hury Res.	2·09	81	*Shetland*	Lerwick Observatory ..	1·40	67
Norl'd.	Newcastle, Leazes Pk. ..	1·81	91	*Ferm.*	Crom Castle	1·18	42
,,	Bellingham, High Green	1·44	60	*Armagh*	Armagh Observatory ..		
,,	Lilburn Tower Gdns. ..	1·79	78	*Down*	Seaforde	1·14	43
Cumb.	Geltsdale	2·31	89	*Antrim*	Aldergrove Airfield ..	1·22	54
,,	Keswick, High Hill ..	2·24	70	,,	Ballymena, Harryville..	1·92	69
,,	Ravenglass, The Grove	1·62	58	*L'derry*	Garvagh, Moneydig ..	1·50	59
Mon.	Abergavenny, Larchfield	2·28	85	,,	Londonderry, Creggan	1·64	63
Glam.	Ystalyfera, Wern House	2·29	66	*Tyrone*	Omagh, Edenfel ..	1·32	51